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Applying GQM to Improve Software Predictability

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Outline

- Overview
- Metrics taxonomy and dataset
- Analysis examples
- Conclusions

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Capability Overview

- Goal-Question-Metric (GQM) framework used to develop a comprehensive set of measures related to software cost, schedule and quality estimation
- Incorporated into Cost Xpert product line
  - Centralized process database supporting queries and analysis
  - Pre-defined metrics analysis templates
- Organization-wide solution for metrics storage and data analysis
  - Project managers, metrics analysts and Systems/Software Engineering Process Groups can define estimation processes, calibrate estimation model parameters, create estimation templates, track projects, perform process improvement tradeoffs and related quantitative analyses
  - Executive management can assess process performance against quantitative goals and evaluate improvement initiatives at different levels in the organization

Goal-Question-Metric

- GQM is a framework for developing a metrics program [1]
- Steps:
  - Generate a set of organizational goals
    - What do you want to improve?
  - Derive a set of questions relating to the goals
    - Answers provide visibility into meeting the goals
  - Develop a set of metrics needed to answer the questions

[1] Victor Basili, *Software Modeling and Measurement: The Goal/Question/Metric Paradigm*, CS-TR-2956, University of Maryland, 1992

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GQM Goal Definition Template

- Purpose: To (characterize, evaluate, predict, motivate, etc.) the (process, product, model, metric, etc.) in order to (understand, assess, manage, engineer, learn, improve, etc.) it.
- Perspective: Examine the (cost, effectiveness, correctness, defects, changes, product metrics, reliability, etc.) from the point of view of the (developer, manager, customer, corporate perspective, etc.)
- Environment: The environment consists of the following: process factors, people factors, problem factors, methods, tools, constraints, etc.

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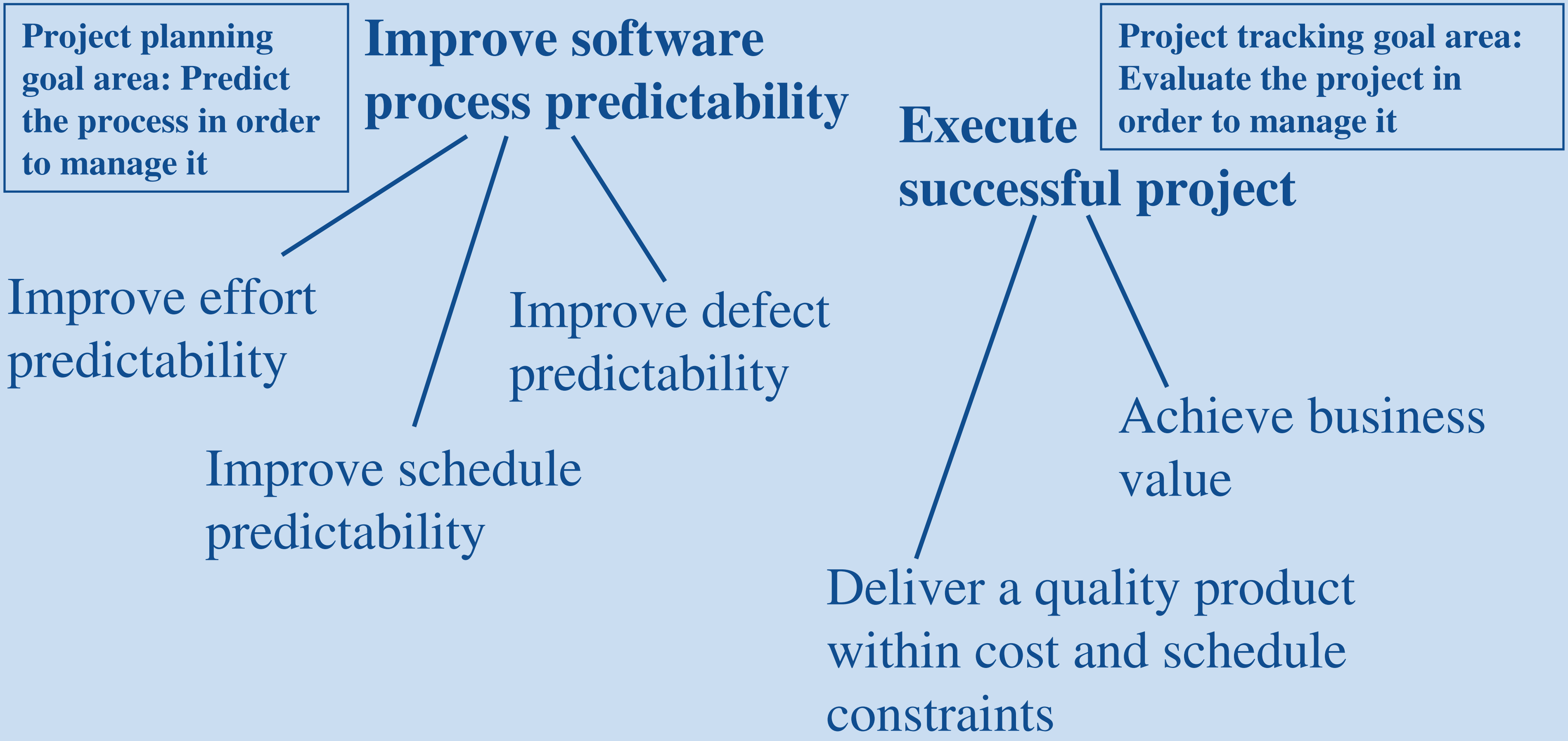
Metrics Taxonomy Elements

- Goal context definitions
- Goals (~15)
- Questions (~75)
- Metrics (indicators) (~65 not including variants)
  - Multiple analysis categories
  - Metric variants
    - E.g. multiple datasets, Pareto distributions, linear vs. exponential regression, linear vs. logarithmic scales, control chart limit options, discrete vs. continuous distributions, other chart visualization options, etc.
  - Some metric indicators address multiple questions

Goal Trees (1/2)



Project planning goal area: Predict the process in order to manage it

Improve software process predictability

Improve effort predictability

Improve schedule predictability

Improve defect predictability

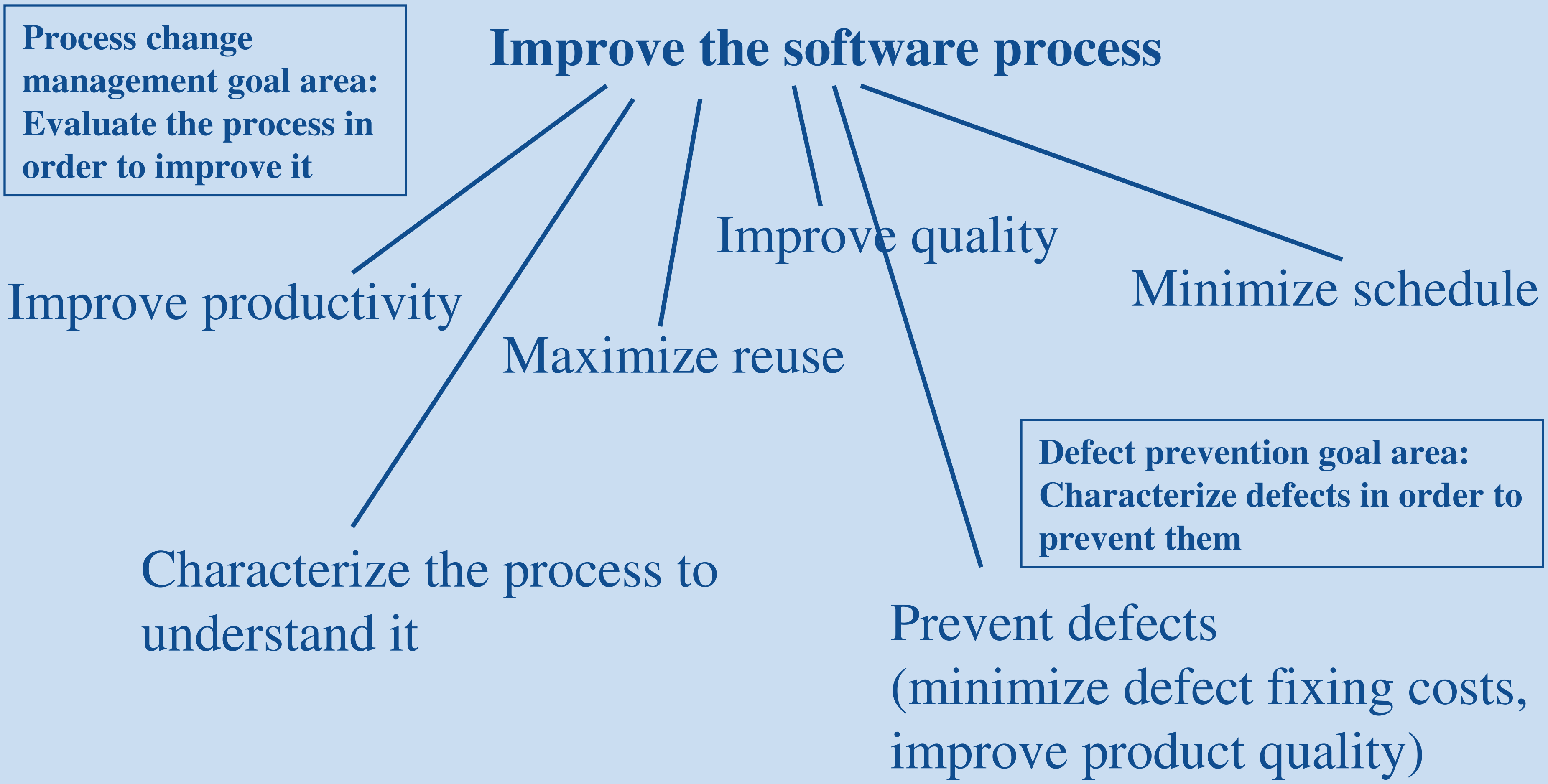
Project tracking goal area: Evaluate the project in order to manage it

Execute successful project

Deliver a quality product within cost and schedule constraints

Achieve business value

Goal Trees (2/2)



Process change management goal area: Evaluate the process in order to improve it

Improve the software process

Improve productivity

Characterize the process to understand it

Maximize reuse

Improve quality

Prevent defects (minimize defect fixing costs, improve product quality)

Minimize schedule

Defect prevention goal area: Characterize defects in order to prevent them

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Sample Organizational Questions

- Process database query and analysis capabilities allows you to answer the following types of questions:
  - What is the accuracy of our cost estimates against actuals?
  - What is the cost and schedule performance expected across different department or product lines?
  - Have process improvement initiatives paid off in terms of productivity gains?
  - How do we compare against the industry competition and best-in-class?
  - Is the defect density of our products decreasing over time?
  - What is the impact on process performance of a given project factor?
  - Does our risk management process reduce the risk profile on projects?

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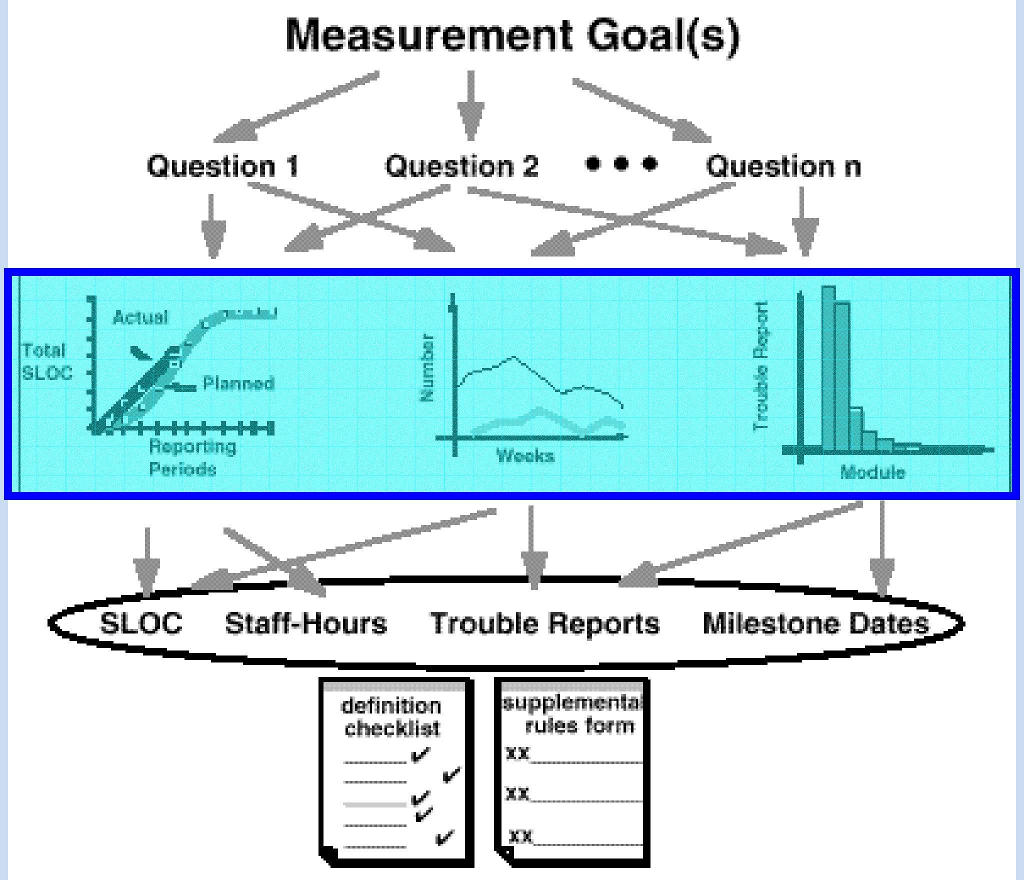
Metrics Analysis Categories

- Factor Analysis
- Process Trends
- Benchmarking
- Process Control
- Calibration
- Distributions
- Project Tracking
- *These categories sometimes overlap*



Metrics Analysis Dataset (1/3)

- Calibrated estimation model coefficients
  - Equation parameters to estimate top-level effort, schedule, defects, pages
    - Linear and exponential terms
    - Per project type
  - Lifecycle phase/activity distribution percentages
  - Factor effort multipliers
- Model inputs
  - Product size (volume)
    - {SLOC, function points, use cases, UML entities, Mark II function points, object metrics, GUI metrics, feature points, Internet points, capability requirements, custom size measures}
    - New, modified, reused, COTS, derived equivalent sizes
    - Per module, iteration

Metrics Analysis Dataset (2/3)

- Model inputs (continued)
  - Environmental factors and constraints
    - Exponential scale factors (5)
    - Linear cost factors (35)
      - Personnel, platform, project, product, task assignment, internet, custom factors
    - Project constraints (4)
- Model outputs
  - Effort, schedule, cost, defects, pages
  - Per phase, activity, labor category

Metrics Analysis Dataset (3/3)

- Historical actuals for all estimation inputs and outputs
- Derived process measures
  - Estimation figures of merit
    - Relative error, mean magnitude of relative error, prediction level
      - For effort, schedule and defect estimation
      - Per project type or other portfolio
  - Process performance
    - Productivity, defect density, CPI, SPI, business value attainment, etc.
      - Some by phase or activity

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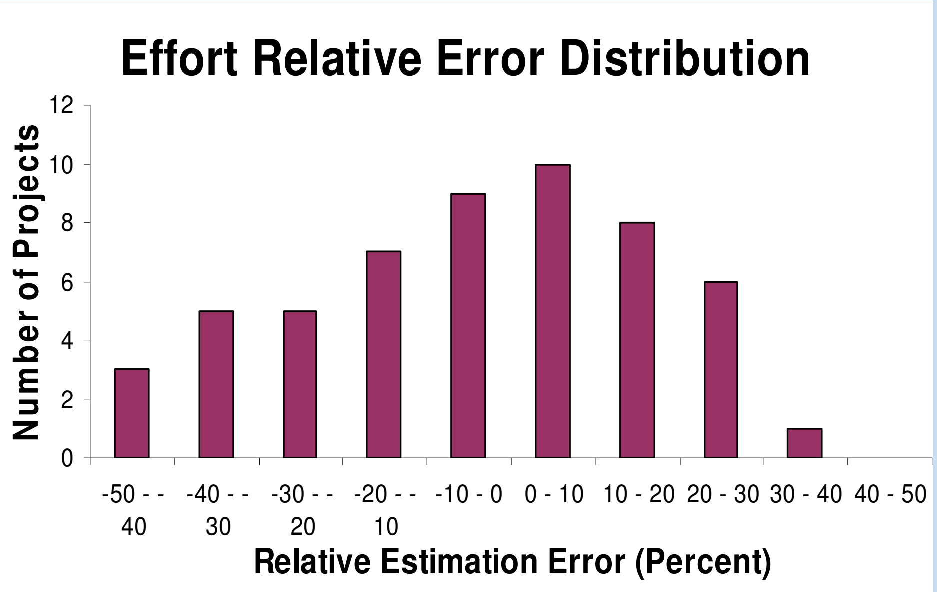
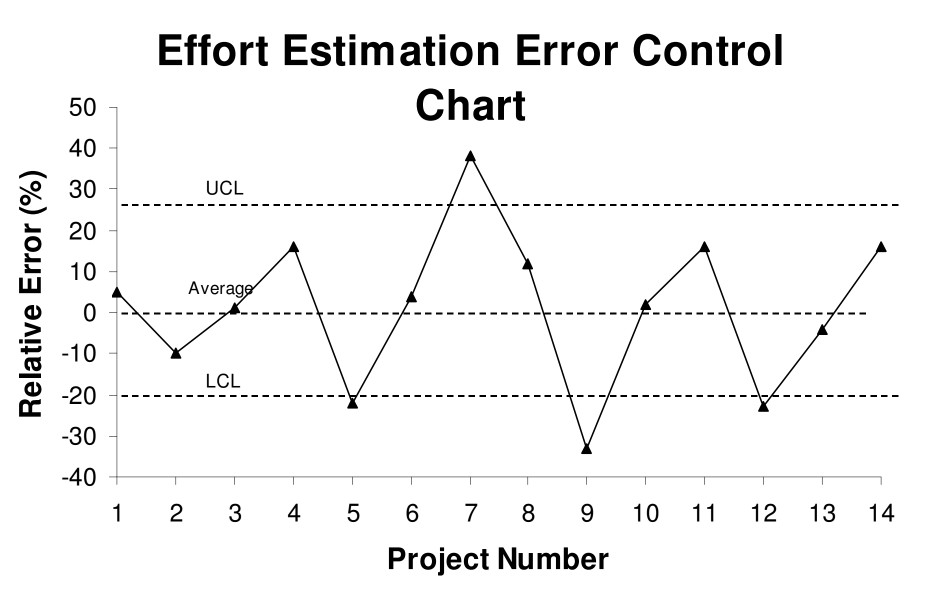
Calibration Examples

Goal: Improve effort predictability
Question: How accurate are post-calibrated effort estimates
Metric: Relative effort error distribution



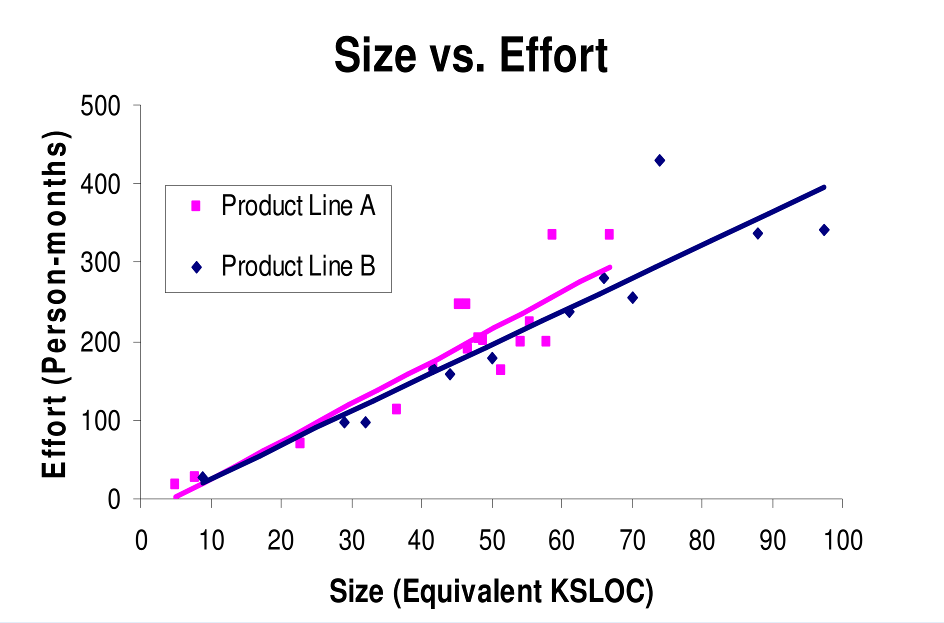
Goal: Improve effort predictability
Question: Is the effort estimation process under control?
Metric: Relative effort error control chart



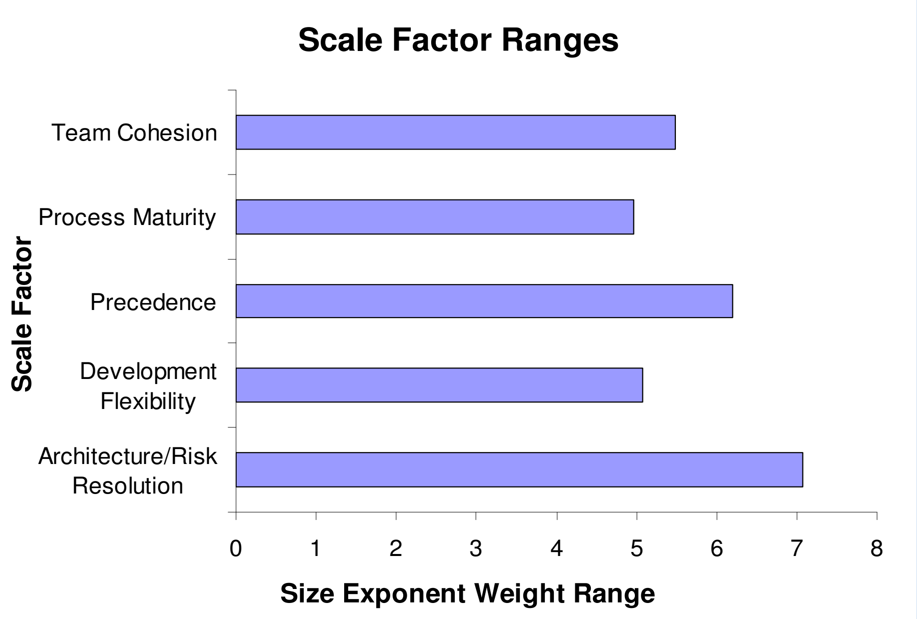
Factor Analysis Examples

Question: Improve effort predictability
Question: How can we predict effort?
Metric: Size vs. effort correlation

- Showing multiple datasets also answers questions comparing project subgroups



Goal: Improve effort predictability
Question: What are the relative impacts of the scale factors?
Metric: Size exponent weight range per scale factor



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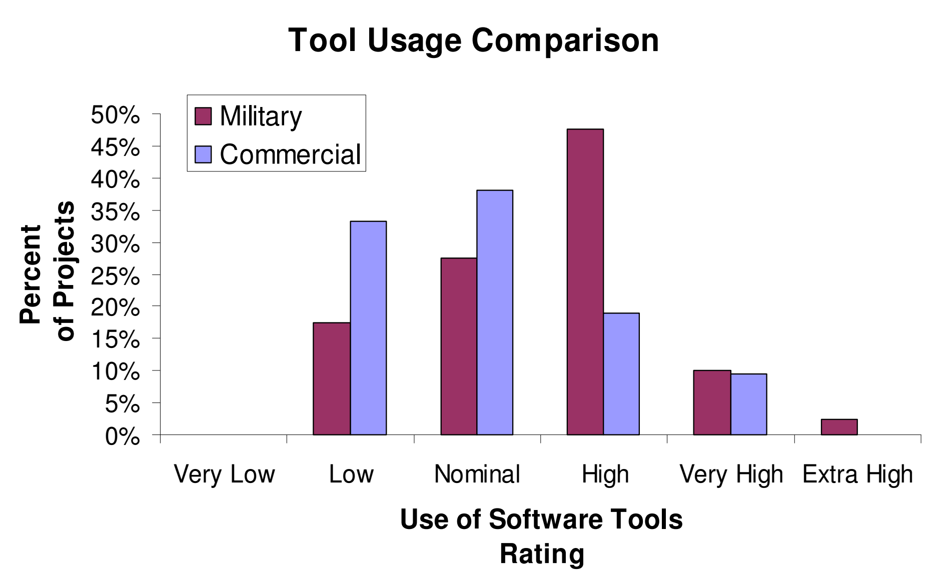
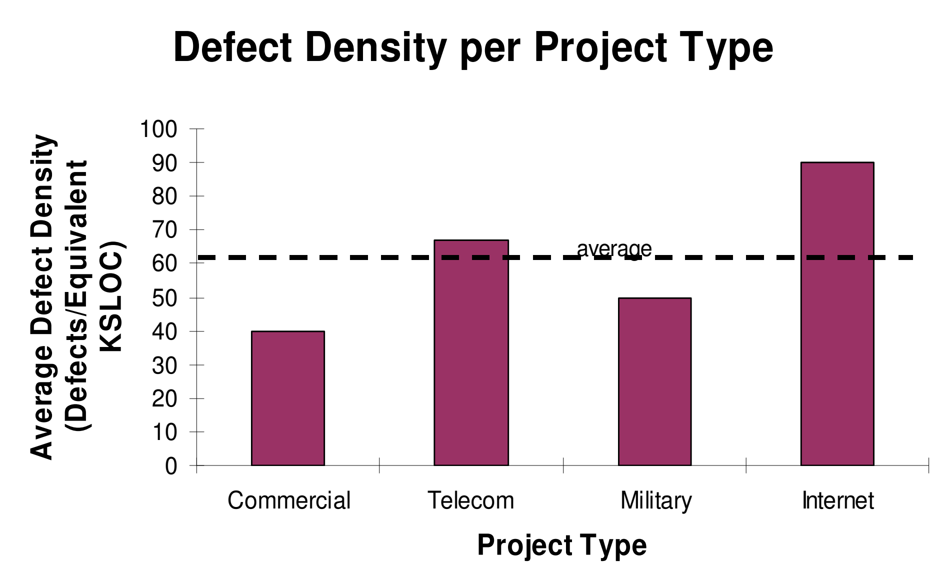
Benchmarking Examples (1/2)

Goal: Characterize the process to understand it
Question: Does the profile of tool usage differ between project subgroups?
Metric: Frequency histogram of tool usage ratings

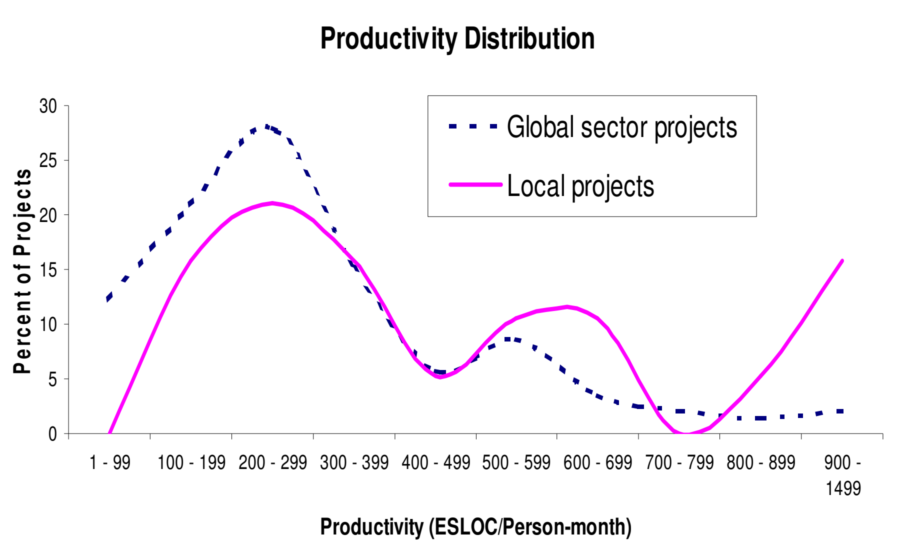
Goal: Improve quality
Question: How does defect density compare among project subgroups?
Metric: Average Defects/KSLOC by project type





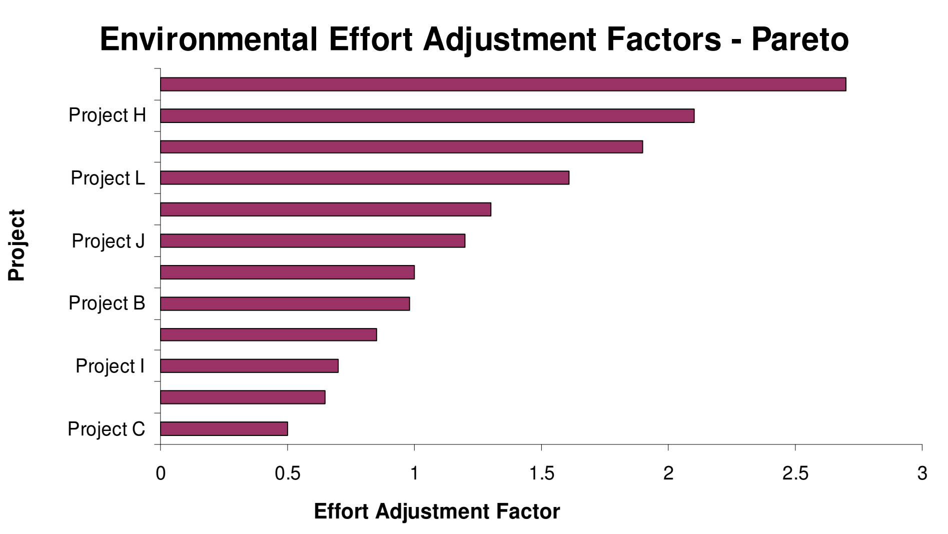
Benchmarking Examples (2/2)

Goal: Evaluate the process in order to {understand, improve} it
Question: How does productivity compare between project subgroups?
Metric: Continuous frequency histogram of actual productivity per subgroup



Goal: Characterize the process in order to understand it
Question: How does the effort adjustment factor compare among projects?
Metric: Effort adjustment factor per project

- Pareto view also answers questions about which projects are most effort-intensive



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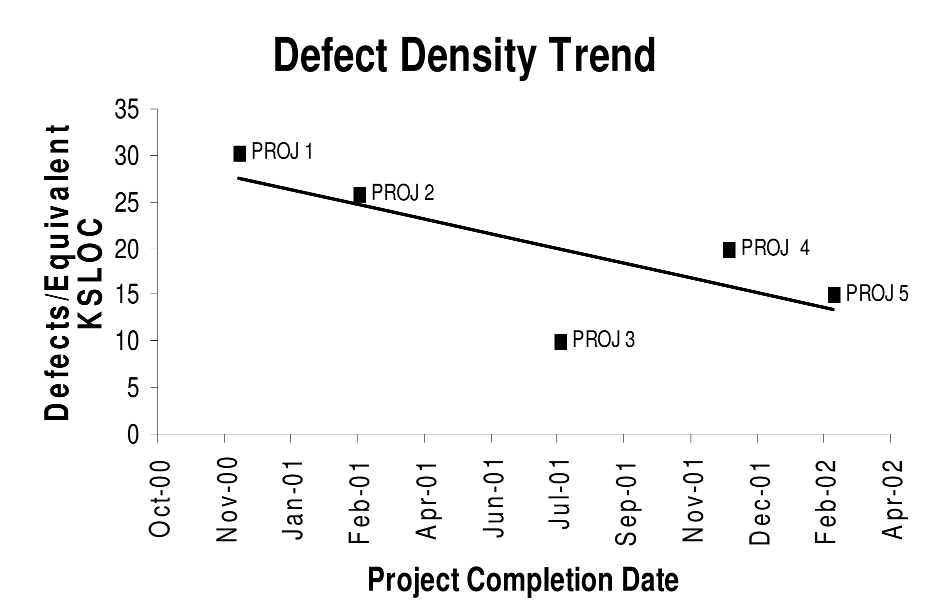
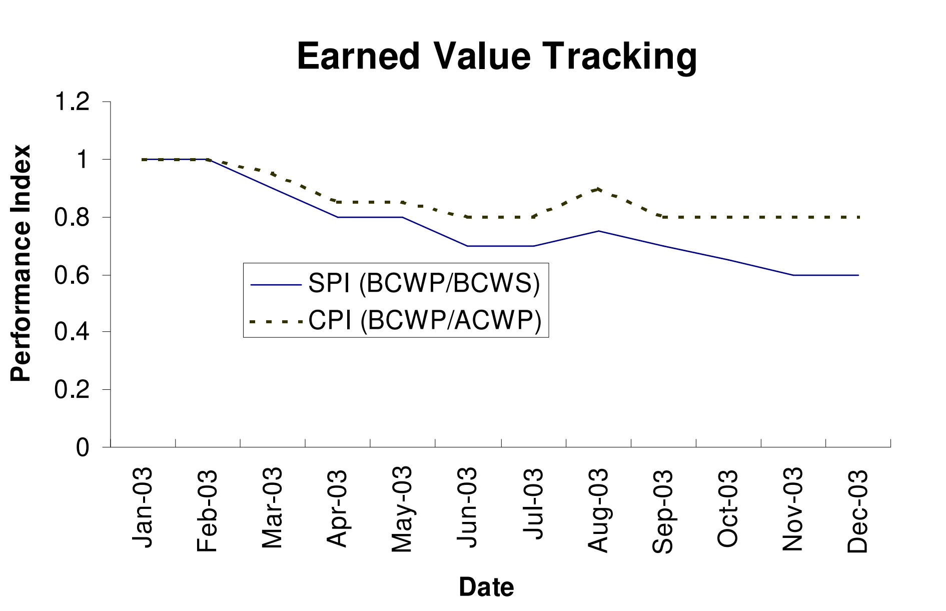
Trend Analysis Examples

Goal: Improve quality
Question: Is defect density decreasing over time?
Metric: Defect density trend chart of completed projects



Goals: Adhere to cost and schedule budgets (current project)
Questions: What are the cost and schedule variances?
Metrics: Cost performance index (CPI) and schedule performance index (SPI) trends



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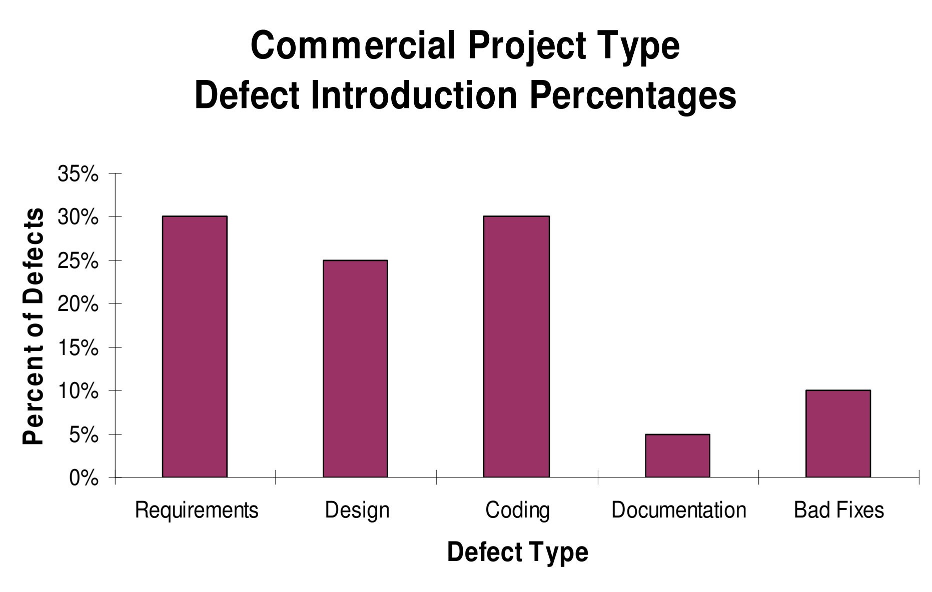
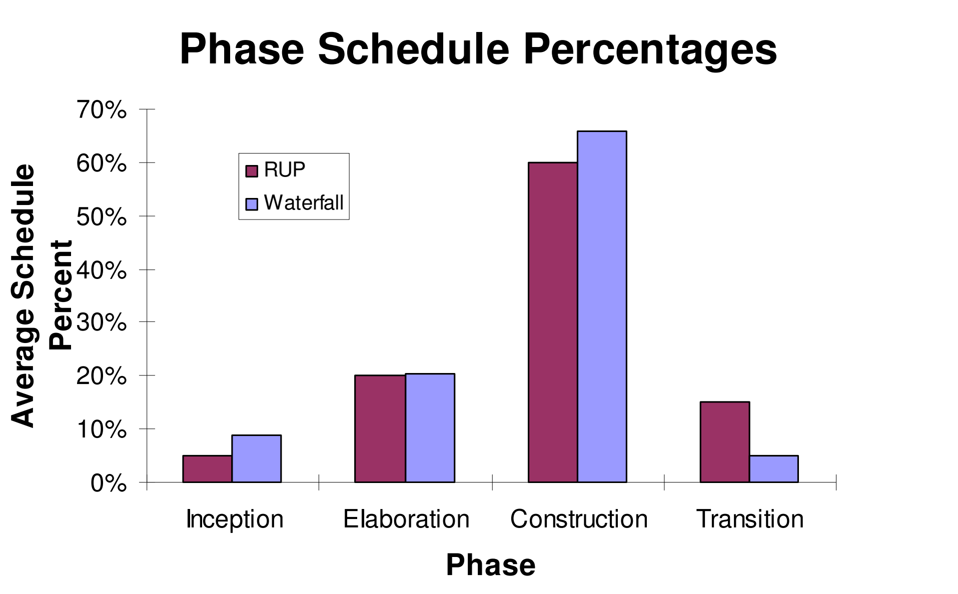
Distribution Examples

Goal: Improve quality
Question: What are high-leverage opportunities for defect prevention?
Metric: Defect category distributions

Goal: Minimize schedule
Question: Where is the cycle-time taken in the lifecycle phases?
Metric: Percent of schedule per lifecycle phase

- Clustered bar chart also answers lifecycle benchmarking questions





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Conclusions

- GQM is a handy organizer
- Estimation models naturally support diverse process goal areas
  - Rich estimation dataset allows for a wide range of process analyses
- Automated analysis quickly pays for itself
  - Pre-defined templates save time
  - Existing GQM coverage already addresses primary process goals
  - Indicator visualizations support quicker insight and group understanding; it's easier to discover trends and relationships
- Ongoing data collection, prediction model tuning, and pro-active process feedback are essential for continuous improvement
- A repeatable estimation process impacts the bottom line
  - decreased project overruns, increased profits and ROI